UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

WALESKA TROVISCO CALDAS

**Relationship between malocclusion severity and treatment stability
in Class II nonextraction treatment**

**Relação entre o grau de severidade e a estabilidade do tratamento
sem extração da má oclusão de Classe II**

BAURU
2018

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Tese constituída por artigos apresentada à Faculdade de Odontologia de Bauru da Universidade de São Paulo para obtenção do título de Doutor em Ciências no Programa de Ciências Odontológicas Aplicadas, na área de concentração Ortodontia.

Orientador: Prof. Dr. Guilherme Janson

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ABSTRACT

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Relationship between malocclusion severity and treatment stability in Class II nonextraction treatment

Introduction: When planning Class II malocclusion treatment it is important to consider the magnitude of the anteroposterior discrepancy, the treatment time, the amount of patient compliance needed and also the long-term stability of the results obtained. The aim of this study was to evaluate the Class II malocclusion nonextraction treatment stability, according to the initial anteroposterior discrepancy severity. **Methods:** Two groups of patients were selected according to the initial malocclusion severity. The Half-cusp Class II Group comprised 30 patients (16 boys, 14 girls) with an initial mean age of 13.15 years (S.D. 3.62) and the Complete Class II Group comprised 30 patients (15 boys, 15 girls) with an initial mean age of 11.99 years (S.D. 1.26). Lateral cephalograms, panoramic radiographs and dental casts were obtained at pretreatment (T1), posttreatment (T2), and at a minimum period of 2 years posttreatment (T3). Intragroup comparisons of changes in variables during the posttreatment period (T3–T2) were made with paired t tests. The initial cephalometric characteristics and malocclusion severity, changes during the treatment period and during the posttreatment period were compared between groups using t tests. A multiple linear regression analysis was used to evaluate the influence of pretreatment characteristics and amount of treatment changes in the amount of posttreatment relapse. Results were regarded as significant at $p < 0.05$. **Results:** During the posttreatment period (T2–T3) there were no significant differences between groups. The occlusal analysis demonstrated a small but significant relapse of molar relationship for both groups. The initial amount of overjet, the severity of canine and molar relationships and the amount of anteroposterior changes during treatment were significantly correlated to the amount of posttreatment molar relationship relapse. When subgroups of patients with matching treatment time were compared, there was significantly greater relapse in molar relationship in the Complete Class II Group. **Conclusions:** The initial Class II malocclusion anteroposterior discrepancy severity demonstrated a significant influence on the amount of posttreatment relapse. When treated without extractions, complete Class II malocclusion presented greater relapse than a less severe Class II molar relationship.

Keywords: Orthodontics. Malocclusion, Angle Class II. Long-term Effect. Recurrence.

RESUMO

RESUMO

Introdução: Durante o planejamento do tratamento da má oclusão de Classe II é importante considerar a magnitude da discrepância ântero-posterior, o tempo de tratamento, a necessidade de cooperação do paciente, assim como a estabilidade em longo prazo dos resultados obtidos. O objetivo do presente estudo foi avaliar a estabilidade do tratamento sem extrações da má oclusão de Classe II, de acordo com a severidade da discrepância ântero-posterior inicial. **Métodos:** Dois grupos de pacientes foram selecionados de acordo com a severidade inicial da má oclusão. O Grupo Meia Classe II compreendeu 30 pacientes (16 meninos, 14 meninas) com idade média inicial de 13,15 anos (D.P. 3,62) e o Grupo Classe II Completa compreendeu 30 pacientes (15 meninos, 15 meninas) com idade inicial média de 11,99 anos (D.P. 1,26). Radiografias em norma lateral, radiografias panorâmicas e modelos de estudo foram obtidos pré-tratamento (T1), pós-tratamento (T2), e após um período mínimo de 2 anos pós-tratamento (T3). As comparações intragrupos das alterações das variáveis durante o período de pós-tratamento (T3-T2) foram realizadas por testes t pareados. As características cefalométricas e severidade da má oclusão inicial, alterações durante os períodos de tratamento e pós-tratamento foram comparadas entre os grupos por testes t. Uma análise de regressão linear múltipla foi conduzida para avaliar a influência das características pré-tratamento e da quantidade de alterações com o tratamento sobre a recidiva pós-tratamento. Os resultados foram considerados significantes para $p < 0,05$. **Resultados:** Durante o período de pós-tratamento (T2-T3) não foram encontradas diferenças significantes entre os grupos. A avaliação oclusal demonstrou discreta mas significativa recidiva da relação molar em ambos os grupos. A severidade inicial da sobressaliência, das relações canino e molar e a quantidade de alteração anteroposterior com o tratamento foram significativamente correlacionadas à recidiva da relação molar. Quando subgrupos de pacientes com tempos de tratamento compatíveis foram comparados, foi encontrada recidiva significativamente maior da relação molar no Grupo Classe II Completa. **Conclusões:** A severidade da discrepância ântero-posterior inicial da má oclusão de Classe II demonstrou influenciar significativamente a quantidade de recidiva pós-tratamento. Quando tratada sem extrações, a má oclusão de Classe II completa apresentou maior recidiva que uma relação molar Classe II menos severa.

Palavras-chave: Ortodontia. Má oclusão de Angle Classe II. Efeitos a Longo Prazo. Recidiva.

TABLE OF CONTENTS

1	INTRODUCTION	15
2	ARTICLES	19
2.1	ARTICLE 1 - Relationship between malocclusion severity and treatment stability in Class II nonextraction treatment	20
2.2	ARTICLE 2 - Relationship between malocclusion severity and occlusal stability in Class II nonextraction treatment	44
3	DISCUSSION	67
4	FINAL CONSIDERATIONS	73
	REFERENCES	77
	APPENDIXES	81
	ANNEXES	85

1 INTRODUCTION

1 INTRODUCTION

Class II malocclusions can be treated with many appliances and treatment protocols according to the characteristics of the problem, such as anteroposterior discrepancy severity, age, and patient compliance (CLEALL; BEGOLE, 1982).

For a treatment method to be efficient, it must be able to produce the best results in the least time (HORNBY; COWIE; LEWIS, 1974), with less patient and professional distress. It has been demonstrated that the treatment efficiency of Class II malocclusion is directly related to the initial severity of the anteroposterior discrepancy (JANSON et al., 2009a). However, investigations have traditionally been concerned with the effects of orthodontic treatment, rather than with the severity of Class II malocclusion and its influence on treatment stability (VIG et al., 1990; JANSON et al., 2009a).

In addition to treatment efficiency, long-term stability is a primary goal in orthodontics, which can be difficult to obtain (UHDE; SADOWSKY; BEGOLE, 1983; LITTLE; RIEDEL; ARTUN, 1988). Studies have shown that, even though improvement can be obtained through orthodontic treatment, there is a tendency of relapse to the original malocclusion many years after appliance removal (ELMS; BUSCHANG; ALEXANDER, 1996; JANSON et al., 2004b). Consequently, every effort should be directed to minimize the risks that can compromise the results of orthodontic treatment (JANSON et al., 2010).

It has been stated that the greater severity of molar relationship at the beginning of treatment and consequently the greatest amount of correction during treatment can influence the maintenance of long-term results (NASHED; REYNOLDS, 1989).

Studies that assessed patients presenting Class II malocclusion have demonstrated that the greater the treatment changes, the greater will be the relapse tendency of dental relationships (YAVARI et al., 2000; JANSON; ARAKI; CAMARDELLA, 2012). A statistically significant correlation between treatment changes in overjet, overbite, and molar and canine relationships with posttreatment changes has been shown in patients treated without extractions (JANSON et al., 2009a; JANSON; ARAKI; CAMARDELLA, 2012).

Accordingly, studies have demonstrated that treatment stability is not dependent on the treatment protocol but rather on the amount of changes during treatment (FIDLER et al., 1995; DE FREITAS et al., 2007; JANSON et al., 2009a; JANSON et al., 2010).

It is known that the severity of malocclusion, especially the severity of the Class II malocclusion when treated without extractions, can significantly increase treatment time (JANSON et al., 2007; JANSON et al., 2009b). Moreover, more severe anteroposterior discrepancies requires more patient compliance in using the extraoral headgear and intermaxillary elastics (JANSON et al., 2006).

Accordingly, It has been demonstrated that the greater the Class II anteroposterior discrepancy severity and the older the patient, the smaller the probability of nonextraction correction of the malocclusion (JANSON et al., 2004a).

When planning Class II malocclusion treatment it is necessary to consider the magnitude of the anteroposterior discrepancy, the treatment time, the amount of patient compliance and also the long-term stability of the results obtained (JANSON et al., 2004a; JANSON et al., 2009b). Thus, the question whether the nonextraction treatment approach in patients with more severe initial anteroposterior dental discrepancies results not only in increased treatment time and need for patient compliance but also in a lower success rate in the long-term, remains.

Consideration of these parameters prior to treatment would eliminate several retreatments and inconveniences in the relationship among doctor, patient, and parents, in which an initial Class II nonextraction treatment may be reversed to a 2-maxillary premolar extraction treatment (SHIA, 1986).

Stability of dental relationships is the most important aim to be achieved (SADOWSKY; SAKOLS, 1982). Even though posttreatment changes of the skeletal characteristics are useful to the researcher, it is also important to analyze the occlusal features, which are the major reasons for patients' complaints. However, skeletal stability should also be aimed, because changes in the apical base relationship may reflect in changes in tooth position (JANSON; ARAKI; CAMARDELLA, 2012).

Therefore, the aim of this study was to evaluate the cephalometric and occlusal Class II malocclusion nonextraction treatment stability, according to the initial anteroposterior discrepancy severity.

2 ARTICLES

2 ARTICLES

The articles presented in this Thesis were written according to the American Journal of Orthodontics and Dentofacial Orthopedics instructions and guidelines for article submission (Annex B).

- **Article 1** - Relationship between malocclusion severity and treatment stability in Class II nonextraction treatment
- **Article 2** - Relationship between malocclusion severity and occlusal stability in Class II nonextraction treatment

2.1 ARTICLE 1

RELATIONSHIP BETWEEN MALOCCLUSION SEVERITY AND TREATMENT STABILITY IN CLASS II NONEXTRACTION TREATMENT

Introduction: When planning Class II malocclusion treatment it is important to consider the magnitude of the anteroposterior discrepancy, the treatment efficiency and the long-term stability of the results obtained. The aim of this study was to cephalometrically evaluate the Class II malocclusion nonextraction treatment stability, according to the initial anteroposterior discrepancy severity. **Methods:** The Half-cusp Class II Group comprised 30 patients (16 boys, 14 girls) with an initial mean age of 13.15 years (S.D. 3.62). The Complete Class II Group comprised 30 patients (15 boys, 15 girls) with an initial mean age of 11.99 years (S.D. 1.26). Lateral cephalograms, panoramic radiographs and dental casts were obtained at pretreatment (T1), posttreatment (T2), and at a minimum period of 2 years posttreatment (T3). The initial cephalometric characteristics and malocclusion severity, changes during the treatment period and during the posttreatment period were compared between groups using t tests. A multiple linear regression analysis was used to evaluate the influence of pretreatment characteristics and amount of treatment changes in the amount of posttreatment relapse. **Results:** During the posttreatment period there were no significant intergroup differences. The initial overjet and molar relationship severities and the amount of molar relationship correction were significantly correlated to the amount of posttreatment molar relationship relapse. When subgroups of patients with matching treatment time were compared, there was significantly greater relapse in molar relationship in the Complete Class II Group. **Conclusions:** The initial Class II malocclusion anteroposterior discrepancy severity demonstrated a significant influence on the amount of posttreatment relapse.

INTRODUCTION

Long-term stability is a very important concern in orthodontic treatment planning, since studies have demonstrated that, even though improvement can be obtained through orthodontic treatment, there is a tendency of relapse to the

original malocclusion after appliance removal.^{1,2} Consequently, every effort should be directed to minimize the risks that can compromise the results of orthodontic treatment in the long-term,³ such as knowing which treatment protocols present the best success rates.

It has been demonstrated that treatment efficiency of Class II malocclusion is directly related to the initial severity of the anteroposterior discrepancy.⁴ However, investigations have traditionally been concerned with the effects of orthodontic treatment, rather than with the severity of Class II malocclusion and its influence on treatment stability.^{4,5}

Studies have suggested that the greater the treatment changes are, the greater will be the relapse tendency of the dental relationships obtained with Class II malocclusion treatment.^{6,7} A significant correlation between treatment changes in overjet, overbite, and molar and canine relationships with posttreatment relapse has been shown in patients treated without extractions.^{7,8} However, none of these studies have evaluated groups of patients divided according to the initial Class II molar relationship severity.

Thus, the question whether the nonextraction treatment approach in patients with more severe Class II dental discrepancies results not only in increased treatment time^{4,9} and need for patient compliance¹⁰ but also in greater relapse in the long-term, remains.

Stability of both dental and skeletal relationships is a very important aim to be achieved,¹¹ since changes in the apical base relationship may reflect in changes in tooth position⁷. Therefore, the aim of this study was to cephalometrically evaluate Class II malocclusion nonextraction treatment stability, according to the initial anteroposterior discrepancy severity.

MATERIAL AND METHODS

Ethical approval was obtained from the Ethics in Research Committee of Bauru Dental School, University of São Paulo, Brazil, before the study was conducted. The sample was retrospectively selected from the files of the orthodontic department at Bauru Dental School, University of Sao Paulo, Brazil, which include over 4000 documented treated patients.

The sample size was calculated based on an alpha significance level of 5% and beta of 20% to detect a mean difference of 0.34mm with a standard deviation of

0.42mm in molar relationship change between the posttreatment and follow-up stages.⁷ The sample size calculation showed that a sample size of 25 patients was needed.

Two groups of patients were selected and divided according to the initial Class II malocclusion severity. The Half-cusp Class II Group comprised 30 patients (16 boys, 14 girls) with bilateral half-cusp Class II malocclusion (molar relationship^{12,13}) at an initial mean age of 13.15 years (S.D. 3.62). The Complete Class II Group comprised 30 patients (15 boys, 15 girls) who initially had bilateral complete Class II malocclusion (molar relationship) at an initial mean age of 11.99 years (S.D. 1.26).

Molar relationships were assessed on the study casts, by using the location of the mesiobuccal cusp of the maxillary first molar and the mesial buccal groove of the mandibular first molar as reference points. Sample selection was based exclusively on the anteroposterior dental relationship at T1, regardless of any other dentoalveolar or skeletal characteristic.

The additional selection criteria were: (1) Presence of all permanent teeth up to the second molars at T2; (2) All patients should have been treated with a 1-phase treatment protocol without extractions; (3) Successful treatment to at least a Class I molar relationship.

Patients who were submitted to orthopedic treatment or who did not present any of the above mentioned criteria were automatically excluded from the study.

The mechanics in both groups consisted of standard fixed edgewise or Roth preadjusted appliances with 0.022 X 0.028-inch slots, associated with extraoral headgear to distalize the maxillary teeth or restrict their forward displacement. Class II elastics were also used when applicable, to aid in correcting the Class II anteroposterior relationship. The usual wire sequence was 0.015-in Twist-Flex or 0.016 Nitinol wire, followed by 0.016-, 0.018-, and 0.020-in, and finally a 0.021x0.025 or an 0.018 X 0.025-inch stainless steel archwires (all from 3M Unitek, Monrovia, Calif). Deep overbites were usually corrected by reversed and accentuated curves of Spee.

After the active treatment period, a Hawley plate was used for retention in the maxillary arch during a mean period of 1 year (6 months all day and 6 months bedtime only), and a canine-to-canine fixed retainer was bonded in the mandibular arch and recommended to be maintained for at least three years.

Cephalometric analysis

Lateral cephalograms of the experimental groups were obtained from each subject at pretreatment (T1), posttreatment (T2), and at long-term posttreatment (T3). Because of the long time between the evaluation stages, the lateral headfilms were obtained with various X-ray machines that produced different magnification factors of the images, between 6% and 10.94%. The cephalograms were digitized (MICROTEK ScanMaker, model i800), traced and analyzed with Dolphin Imaging 11.5 (Patterson Dental Supply, Inc., Chatsworth, California, USA), which corrected the image magnification factors of the images.

A customized cephalometric analysis generated 26 variables, 8 angular and 18 linear, for each tracing (Table II).

Cast and Panoramic Radiograph Analyses

To evaluate the initial malocclusion severity and final occlusal results of the experimental group, the peer assessment rating (PAR) index¹⁴ was calculated on the pre- and posttreatment dental study casts of each patient¹⁵ by one examiner. Initial and final occlusal characteristics were ranked by scores regarding molar and premolar anteroposterior relationship (AP), overjet (OVJ), overbite (OVB), midline (ML), crossbite (CB), and crowding (C) to quantify the initial malocclusion severity (PAR1), the occlusal treatment results (PAR2), and the PAR treatment changes (PAR1–PAR2),^{16,17} which is a better estimate of the occlusal changes.¹⁸

To assess the occlusal and radiographic results and stability of orthodontic treatment the Objective Grading System (OGS), developed by The American Board of Orthodontics was used.¹⁹ This system for scoring dental casts and panoramic radiographs contains eight criteria: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulation.

Error study

A month after the first measurements, 30 radiographs and 30 study models were randomly selected and remeasured by the same examiner (W.C.). The random errors were calculated according to Dahlberg's formula ($Se^2 = \sum d^2/2n$),²⁰ and the systematic errors were evaluated with dependent t tests, at $P < 0.05$.^{21,22}

Statistical analyses

Normal distribution was verified by Kolmogorov-Smirnov tests. The results were nonsignificant for all variables. Therefore, intergroup comparability regarding the ages at the different stages and observational periods were performed with t tests. Intergroup sex distribution was compared with chi-square tests.

The intergroup initial cephalometric characteristics and malocclusion severity, and the changes during the treatment (T2–T1) and the posttreatment (T3–T2) periods were compared with t tests.

A multiple linear regression analysis was performed to determine the influence of treatment time, active retention time, initial malocclusion severity (PAR T1), initial Overjet amount (Overjet T1) and Molar Relationship Discrepancy (Molar Relationship T1), amount of overjet (Overjet T2–T1) and Molar Relationship corrections (Molar Relationship T2–T1) and the quality of the results obtained with treatment (OGS T2) on the amount of relapse of Overjet T3–T2, Molar Relationship T3–T2 and OGS T3–T2.

Results were regarded as significant at $P < 0.05$. These analyses were performed with Statistica for Windows 4.3B (Statsoft, Tulsa, Okla).

RESULTS

Among the 26 variables, none presented systematic errors. The range of random errors were within acceptable levels and varied from 0.846 (Overbite) to 1.64 mm (A-NPerp) for the linear variables and from 1.20 (IMPA) to 1.49 (FMA) for the angular variables.^{8,21}

The groups were comparable regarding the ages at the different stages, follow-up time and sex distribution. The Complete Class II Group presented a significantly longer treatment time (Table II).

The intergroup comparison showed that at pretreatment (T1), the Complete Class II Group presented a significantly greater retrusion of the mandible, resulting in greater severity of the maxilomandibular relationship discrepancy (Wits) than the Half-cusp Class II Group (Table III; Fig 2). The Complete Class II Group presented also significantly greater labial tipping of the mandibular incisors, overjet, molar relationship discrepancy and malocclusion status (PAR).

During treatment, the Complete Class II Group presented significantly greater maxillary forward growth restriction and maxillomandibular relationship

correction (Table IV). The maxillary incisors were significantly more lingually tipped. The overjet and molar relationships presented significantly greater reduction. There were significantly greater changes in the occlusal status.

During the posttreatment period there were no significant intergroup differences (Table V).

The multiple regression analysis showed that the initial amount of overjet, the amount of overjet correction and the amount of molar relationship correction were significantly correlated to the amount of posttreatment overjet increase (Overjet T3-T2, Table VI). Similarly, the initial amount of overjet, initial severity of molar relationship discrepancy and the amount of molar relationship correction were correlated to the molar relationship relapse towards Class II during the posttreatment period (Molar Relationship T3-T2). When the occlusal status relapse was the dependent variable (OGS T3 -T2), the initial molar relationship severity and the amount of molar relationship correction, as well as the quality of the results obtained with treatment (OGS T2) were significantly correlated.

To evaluate whether the treatment time (T2-T1) influenced the long-term posttreatment changes, subgroups with 15 patients of each group with the most comparable treatment times were compared (Table VII). The results showed that only molar relationship presented significantly greater relapse in the Complete Class II Group during the posttreatment period (T3-T2, Table VIII).

DISCUSSION

When planning Class II malocclusion treatment it is important to consider the magnitude of the anteroposterior discrepancy, the treatment time, the amount of patient compliance needed and also the long-term stability of the results obtained.^{4,23}

Since less stability is expected when greater treatment changes are produced,^{6-8,24} it has been suggested that the greater severity of molar relationship at pretreatment and consequently the greatest amount of correction during treatment can influence the maintenance of long-term results.²⁴ Yet, to the best of our knowledge, no previous study has compared Class II treatment stability between two groups of patients with actually distinct Class II molar relationship severities. In the present study, only patients presenting bilateral half-cusp Class II malocclusion or bilateral complete Class II malocclusion were included.

Accordingly, it makes sense that if we aim to evaluate whether greater treatment changes results in greater relapse, only successfully treated patients with respect to the anteroposterior discrepancy should be assessed,¹⁰ otherwise the amount of changes obtained with treatment would not be significantly different between groups after all. Thus, the present study only included patients successfully treated to at least a Class I molar relationship.

The Complete Class II malocclusion Group presented significantly longer treatment time (Table I). This result was expected since it has been demonstrated that the severity of the anteroposterior discrepancy of the Class II malocclusion, when treated without extractions, can significantly increase treatment time.^{4,9,25}

It seems logical that greater corrections take more time. Moreover, when treating more severe malocclusions there may be greater concern with respect to the use of active retention after correction of the anteroposterior discrepancy, which may also increase treatment time, as will be discussed later.

Although no effort was made to match the groups for skeletal characteristics at T1, only 3 of 11 skeletal components showed statistically significant differences between them (Table III; Fig 2). The intergroup comparison showed that at pretreatment (T1), the Complete Class II Group presented significantly greater retrusion of the mandible, resulting in greater severity of the maxillomandibular relationship discrepancy (Wits) than the Half-cusp Class II Group. Greater maxillomandibular discrepancies are expected to follow greater dental discrepancies, with the retrognathic mandible being one of the most common characteristics of Class II division 1 malocclusion.^{26,27} Therefore, it can be assumed that the groups were reasonably matched.

The criteria used for selecting the study sample are reflected in the dentoalveolar measurements at T1. The Complete Class II Group presented significantly greater labial tipping of the mandibular incisors, as usually observed,²⁸ overjet, molar relationship discrepancy and malocclusion status (PAR, Table III).

During treatment, the Complete Class II Group presented significantly greater maxillary forward growth restriction, improving the maxillomandibular relationship, observed by significantly greater reduction of the ANB angle and Wits (Table IV). Studies have demonstrated that improvement in the basal bone relationship in Class II division 1 patients treated with headgear therapy is usually

obtained by inhibition of forward maxillary growth, without significant changes in the mandibular component.^{1,29-31}

Accordingly, once all patients were successfully treated with respect to the initial Class II anteroposterior dental discrepancy, the greater need for changes in the Complete Class II Group resulted in significantly greater lingual tipping of the maxillary incisors, reduction of the overjet and molar relationships and improvement in the occlusal status during treatment.^{1,29,31}

During the posttreatment period there were no significant intergroup differences (Table V).

On the other hand, the multiple linear regression analysis showed that the initial amount of overjet, the amount of overjet correction and the amount of molar relationship correction were significantly correlated to the amount of posttreatment overjet change (Overjet T3-T2, Table VI), which might be perceived by the patient and be the reason for complaints. Similarly, the initial amount of overjet, initial severity of molar relationship discrepancy and the amount of molar relationship correction were correlated to molar relationship relapse towards Class II, during the posttreatment period (Molar Relationship T3-T2). When the occlusal status relapse was the dependent variable (OGS T3 –T2), the initial severity of molar relationship discrepancy, the amount of molar relationship correction, and the quality of the results obtained with treatment (OGS T2) were correlated.

The fact that a positive correlation was found between several pretreatment characteristics and an inverse relationship was found between several treatment changes with the amount of posttreatment anteroposterior relapse (overjet and molar relationship), even though no difference was found between the two Class II severity groups, suggests a tendency for relapse with increased amount of correction, as previously observed.^{1,6-8,24}

Previous studies have also significantly correlated changes in overjet, overbite and molar relationship obtained with treatment to greater posttreatment changes of dental relationships.^{7,8} It seems that studies that have not assessed only successfully treated patients fail to find this correlation, since the absence of this selection parameter may result in smaller treatment changes and consequently in smaller posttreatment relapse.^{3,7,31}

Uhde, Sadowsky and Begole,³² which assessed the long-term stability of dental relationships after orthodontic treatment (12 to 35 years) in Class I and Class

II patients treated with and without extractions, found that a tendency for the overjet to increase during the posttreatment period was seen in all groups, with a slightly but not significantly greater increase in the Class II group (mean of 0.97mm S.D. 1.26) than in the Class I group (mean of 0.50mm S.D. 1.24). Similarly, in the same mentioned study, a slight but not significantly greater increase in overjet was observed in the Class II group treated without extractions (mean of 1.11mm S.D. 1.25), in comparison with the extraction group (mean of 0.57mm S.D. 1.26).

Additionally, it seems that the quality of the occlusal results obtained also play a role in posttreatment relapse,³³ since a positive correlation was observed between the quality of the occlusal results at the end of treatment (T2) and the amount of occlusal status relapse after treatment (T3-T2, Table VI).

To evaluate whether treatment time (T2-T1) influenced the long-term posttreatment changes, subgroups with comparable treatment time were compared (Table VII). The results showed that only molar relationship presented significantly greater relapse in the Complete Class II Group during the posttreatment period (T3-T2) (Table VIII).

These results corroborate with previous studies that suggested that the greater the treatment changes are, the greater will be the relapse tendency of the dental relationships obtained.^{6-8,24,31}

The findings of the present study must be interpreted in the light of the limitations of its retrospective nature, such as the difficulty in estimating the accuracy of data obtained from the dental records with respect to patient compliance in the use of auxiliary devices and retentions. However, the absence of significant differences with respect to the long-term stability between the original groups may be explained by the fact that the increased treatment time in the original Complete Class II Group also involved an increased active retention time. Thus, the stability achieved was probably consequent to the amount of active retention used during the fixed appliance phase of treatment.^{1,34,35}

When 15 patients of each group with the most comparable treatment times were compared, there was significantly greater relapse in molar relationship in the Complete Class II Group. This result emphasizes the importance of not neglecting the necessary active retention time, especially in Class II malocclusion nonextraction treatment.^{3,9,34,36}

It is known that malocclusion severity, especially Class II malocclusion severity, when treated without extractions, can significantly increase treatment time and decrease treatment efficiency.^{3,4} Additionally, more severe anteroposterior discrepancies require more patient compliance in using the extraoral headgear or intermaxillary elastics.¹⁰

The results obtained in the present study provide important clinical implications for the orthodontic treatment of dental Class II malocclusion. When treated without extractions, complete Class II malocclusion may present greater relapse than a less severe Class II molar relationship. However, a severe Class II malocclusion should not discourage nonextraction treatment, with respect to the long-term success of treatment results, if an adequate active retention period is respected after anteroposterior correction.

Still, it is important to evaluate whether each complete Class II patient is likely to accept an expected longer treatment time than different protocols (i.e. two premolar extractions⁹) and to comply with treatment.

CONCLUSIONS

It was concluded that:

1. The initial amount of overjet and the amount of treatment changes in molar relationship were significantly correlated to the long-term posttreatment overjet and molar relationship relapse.
2. When subgroups of patients with matching treatment time were compared, there was significantly greater relapse in molar relationship in the Complete Class II Group.
3. Therefore, initial Class II malocclusion anteroposterior discrepancy severity demonstrated a significant influence on the amount of posttreatment relapse.

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FIGURE CAPTIONS

Fig. 1. Unusual cephalometric variables: 1, Mx1.PP; 2, Mx1-APerp; 3, Mx1-PP; 4, Mx6-APerp; 5, Mx6-PP; 6, Md1-PgPerp, 7, Md1-MP; 8, Md6-PgPerp; 9, Md6-MP.

Fig. 2. Patients mean tracings generated by Dolphin Imaging 11.5 software. A and B are based on the mean tracings to illustrate the pretreatment cephalometric characteristics. **A**, Half-cusp Class II Group at T1; **B**, Complete Class II Group at T1.

Fig 1

Fig 2

Table I. Skeletal and dental cephalometric variables

Skeletal cephalometric variables	
Maxillary component	
SNA (°)	SN to NA angle
A-NPerp (mm)	Distance from A-point to a perpendicular to Frankfurt plane, through Nasion
Co-A (mm)	Condylion to A-point distance
Mandibular component	
SNB (°)	SN to NB angle
Pg-NPerp (mm)	Distance from Pg-point to a perpendicular to Frankfurt plane, through Nasion
Co-Gn (mm)	Condylion to gnathion distance
Maxillomandibular relationship	
ANB (°)	NA to NB angle
Wits (mm)	Distance between perpendicular projections of points A and B on the functional occlusal plane
Vertical component	
FMA (°)	Frankfort plane to mandibular plane angle
SNGoGn (°)	SN to GoGn angle
LAFH (mm)	Distance from ANS to menton
Dental cephalometric variables	
Maxillary dentoalveolar component	
Mx1.PP (°)	Maxillary incisor long axis to palatal plane angle
Mx1-APerp (mm)	Distance between most anterior point of maxillary incisor crown and a line perpendicular to palatal plane, tangent to A point. Reading is negative if the incisal edge is posterior to A point.
Mx1-PP (mm)	Perpendicular distance between incisal edge of maxillary incisor and palatal plane
Mx6-APerp (mm)	Distance between the mesio-buccal cusp tip of the maxillary first molar and a line perpendicular to palatal plane, tangent to A point. Reading is negative if the mesio-buccal cusp tip is posterior to A point.
Mx6-PP (mm)	Perpendicular distance between the mesio-buccal cusp tip of the maxillary first molar and palatal plane
Mandibular dentoalveolar component	
IMPA (°)	Mandibular incisor long axis to mandibular plane angle
Md1-PgPerp (mm)	Distance between most anterior point of mandibular incisor crown and a perpendicular to mandibular plane, tangent to Pg. Reading is negative if the incisal edge is posterior to Pg.
Md1-MP (mm)	Perpendicular distance between incisal edge of mandibular incisor and mandibular plane
Md6-PgPerp (mm)	Distance between the mesio-buccal cusp tip of the mandibular first molar and a line perpendicular to mandibular plane, tangent to Pg. Reading is negative if the mesio-buccal cusp tip is posterior to Pg.
Md6-MP (mm)	Perpendicular distance between the mesio-buccal cusp tip of the mandibular first molar and mandibular plane
Dental relationships	
Overjet (mm)	Distance between incisal edges of maxillary and mandibular central incisors, parallel to the functional occlusal plane
Overbite (mm)	Distance between incisal edges of maxillary and mandibular central incisors, perpendicular to Frankfurt plane
M.Rel (mm)	Distance between mesial points of maxillary and mandibular first molars, parallel to Frankfurt plane. Reading is negative if the mesial point of maxillary first molar is posterior to the mesial point of mandibular first molar.

Table II. Comparability of the experimental groups (T and chi-square tests)

Stage/Period	<u>Half-cusp Class II</u> n = 30		<u>Complete Class II</u> n = 30		p
	Mean	SD	Mean	SD	
Age T1	13.15y	3.62y	11.99y	1.26y	0.119 [†]
Age T2	15.71y	3.40y	15.50y	1.55y	0.765 [†]
Age T3	21.65y	4.97y	21.87y	3.54y	0.853 [†]
Treatment time	2.56y	1.22y	3.51y	1.65y	0.016 ^{†*}
Long-term follow-up time	6.04y	3.35y	6.47y	3.91y	0.670 [†]
Sex	Male 16 (53.3%)	Female 14 (46.7%)	Male 15 (50%)	Female 15 (50%)	0.796 [‡]

[†] t test; [‡] chi-square test.

*Statistically significant at $p < 0.05$.

Table III – Intergroup comparison of the initial cephalometric characteristics and malocclusion severity (T tests)

	<u>Half-cusp Class II</u> n = 30		<u>Complete Class II</u> n = 30		
Variable	Mean	SD	Mean	SD	p
Maxillary component					
SNA	82.49	3.96	81.64	3.50	0.393
A-NPerp	1.14	3.36	0.34	3.07	0.351
Co-A	81.01	4.23	80.99	5.03	0.989
Mandibular component					
SNB	77.73	3.51	75.73	2.84	0.021*
Pg-NPerp	-4.39	5.27	-7.41	4.97	0.029*
Co-Gn	108.00	6.34	105.80	6.69	0.204
Maxillomandibular relationship					
ANB	4.75	2.42	5.89	2.27	0.070
Wits	2.75	2.40	4.68	2.76	0.006*
Vertical component					
FMA	26.46	5.45	26.31	5.04	0.914
SNGoGn	32.82	6.24	32.37	5.47	0.771
LAFH	60.14	4.73	60.85	5.80	0.610
Maxillary dentoalveolar component					
Mx1.PP	113.59	8.17	115.99	8.04	0.266
Mx1-Aperp	3.47	3.36	4.16	2.36	0.376
Mx1-PP	25.53	2.48	26.09	2.37	0.387
Mx6-APerp	-27.61	3.01	-27.40	2.51	0.782
Mx6-PP	19.46	2.25	19.84	2.50	0.542
Mandibular dentoalveolar component					
IMPA	93.92	5.15	97.48	7.11	0.033*
Md1-PgPerp	34.32	3.09	34.05	2.52	0.718
Md1-MP	-9.45	2.78	-8.54	2.89	0.227
Md6-PgPerp	37.59	2.74	37.82	3.43	0.780
Md6-MP	-26.56	2.17	-27.22	2.88	0.326
Dental relationships					
Overjet	5.13	1.96	7.27	3.12	0.003*
Overbite	3.18	1.50	3.29	2.17	0.823
Molar relationship	1.50	1.29	3.94	1.69	<0.001*
PAR	30.77	9.11	41.13	9.86	<0.001*

*Statistically significant at $p < 0.05$.

Table IV - Intergroup comparison of treatment changes – T2-T1 (T tests)

	<u>Half-cusp Class II</u> n = 30		<u>Complete Class II</u> n = 30		
Variable	Mean	SD	Mean	SD	p
Maxillary component					
SNA	-0.42	1.31	-1.38	2.11	0.041*
A-NPerp	-1.50	2.64	-1.85	3.31	0.657
Co-A	1.69	2.58	1.67	3.01	0.980
Mandibular component					
SNB	0.78	1.23	0.97	1.98	0.652
Pg-NPerp	-0.52	4.61	0.47	3.38	0.357
Co-Gn	6.33	5.10	7.08	4.76	0.702
Maxillomandibular relationship					
ANB	-1.18	1.41	-2.30	1.75	0.009*
Wits	-1.36	1.99	-3.86	2.50	<0.001*
Vertical component					
FMA	0.62	3.07	0.78	2.31	0.833
SNGoGn	-0.79	2.84	0.53	3.27	0.104
LAFH	4.26	3.63	6.16	5.79	0.326
Maxillary dentoalveolar component					
Mx1.PP	-1.00	2.12	-4.48	5.04	0.026*
Mx1-Aperp	-0.02	2.54	-1.20	3.30	0.131
Mx1-PP	1.28	1.82	2.21	3.83	0.239
Mx6-APerp	-0.48	2.85	-0.94	4.19	0.135
Mx6-PP	2.29	1.80	2.40	3.73	0.893
Mandibular dentoalveolar component					
IMPA	3.61	4.88	1.69	6.17	0.193
Md1-PgPerp	0.23	2.34	0.38	2.19	0.804
Md1-MP	1.49	2.18	2.45	5.94	0.411
Md6-PgPerp	1.01	3.96	1.90	6.08	0.509
Md6-MP	2.32	2.14	3.48	5.54	0.293
Dental relationships					
Overjet	-2.12	2.01	-4.63	2.81	<0.001*
Overbite	-1.67	1.62	-1.76	1.51	0.813
Molar relationship	-1.99	1.35	-4.11	1.78	<0.001*
PAR	-26.40	8.55	-35.97	10.68	<0.001*

*Statistically significant at $p < 0.05$.

Table V - Intergroup comparison of posttreatment changes – T3-T2 (T tests)

	<u>Half-cusp Class II</u> n = 30		<u>Complete Class II</u> n = 30		
Variable	Mean	SD	Mean	SD	p
Maxillary component					
SNA	0.79	1.92	1.06	1.41	0.145
A-NPerp	-0.05	2.09	0.94	3.04	0.153
Co-A	1.41	1.37	2.60	2.63	0.102
Mandibular component					
SNB	1.63	1.96	0.71	1.31	0.163
Pg-NPerp	1.24	3.32	1.17	4.90	0.398
Co-Gn	2.76	3.61	3.61	3.66	0.320
Maxillomandibular relationship					
ANB	-0.16	1.43	0.35	1.19	0.152
Wits	0.02	1.57	0.77	1.70	0.088
Vertical component					
FMA	-2.10	3.25	-1.14	2.67	0.452
SNGoGn	-3.07	4.45	-1.65	2.39	0.393
LAFH	3.13	1.09	0.87	0.87	0.543
Maxillary dentoalveolar component					
Mx1.PP	-1.89	2.60	0.38	4.84	0.150
Mx1-Aperp	0.06	1.52	0.23	1.35	0.657
Mx1-PP	1.40	1.81	2.21	3.83	0.318
Mx6-APerp	0.43	0.92	0.94	0.20	0.163
Mx6-PP	0.91	5.87	0.10	3.49	0.431
Mandibular dentoalveolar component					
IMPA	-1.25	2.73	-1.04	3.46	0.089
Md1-PgPerp	0.48	3.36	0.01	1.87	0.505
Md1-MP	-1.55	0.32	-0.01	0.67	0.496
Md6-PgPerp	2.01	1.56	1.58	1.02	0.840
Md6-MP	0.97	1.49	0.18	0.52	0.460
Dental relationships					
Overjet	-0.21	0.94	0.09	1.05	0.269
Overbite	0.47	1.18	0.42	1.26	0.872
Molar relationship	0.28	0.82	0.23	0.78	0.098
OGS	-3.13	8.50	-0.80	10.91	0.359

Table VI – Results of multiple linear regression analysis with the amount of Overjet, molar relationship and OGS relapse in the posttreatment period as dependent variables (n=60)

Variables	Overjet T3-T2		Molar Relationship T3-T2		OGS T3-T2	
	r	p	r	p	r	p
Treatment Time	0.05	0.546	0.01	0.831	-0.21	0.127
Active Retention Time	-0.03	0.378	-0.01	0.830	-0.03	0.806
PAR T1	0.02	0.219	0.03	0.066	0.09	0.591
Overjet T1	0.46	0.002*	0.25	0.047*	-0.45	0.305
Overjet T2-T1	-0.57	<0.001*	-0.20	0.101	-0.41	0.319
Molar Relationship T1	0.28	0.067	0.61	<0.001*	0.67	0.045*
Molar Relationship T2-T1	-0.39	0.011*	-0.67	<0.001*	-0.84	0.011*
OGS T2	0.02	0.101	0.01	0.513	0.51	<0.001*

*Statistically significant at $p<0.05$.

Table VII. Comparability of the experimental subgroups with comparable treatment time (T and chi-square tests)

Stage/Period	<u>Half-cusp Class II</u> n = 15		<u>Complete Class II</u> n = 15		p
	Mean	SD	Mean	SD	
Age T1	12.47y	2.03y	12.45y	1.26y	0.975 [†]
Age T2	15.33y	2.14y	15.41y	1.36y	0.898 [†]
Age T3	20.21y	3.69y	22.31y	3.88y	0.141 [†]
Treatment time	2.85y	0.94y	2.96y	1.37y	0.811 [†]
Long-term follow-up time	4.89y	2.56y	6.90y	3.81y	0.101 [†]
Sex	Male 3 (20%)	Female 12 (80%)	Male 5 (33.3%)	Female 10 (66.7%)	0.409 [‡]

[†] t test; [‡] chi-square test.

Table VIII - Intergroup comparison of posttreatment changes – T3-T2 in subgroups with comparable treatment time (T tests)

	Half-cusp Class II n = 15		Complete Class II n = 15		
Variable	Mean	SD	Mean	SD	p
Maxillary component					
SNA	0.50	1.51	0.91	1.34	0.297
A-NPerp	0.02	2.51	0.22	2.79	0.806
Co-A	2.18	1.71	4.02	2.14	0.289
Mandibular component					
SNB	1.51	0.45	0.77	1.15	0.326
Pg-NPerp	1.08	3.33	0.09	3.68	0.445
Co-Gn	3.29	2.56	4.78	1.95	0.889
Maxillomandibular relationship					
ANB	-0.49	1.67	0.13	1.18	0.245
Wits	-0.41	1.60	0.34	1.43	0.188
Vertical component					
FMA	-3.11	6.84	-0.45	2.43	0.168
SNGoGn	-3.73	9.55	-1.63	2.67	0.419
LAFH	2.80	1.79	2.40	1.40	0.945
Maxillary dentoalveolar component					
Mx1.PP	-1.57	1.09	0.03	5.65	0.301
Mx1-Aperp	0.02	1.94	0.60	1.37	0.352
Mx1-PP	-0.58	7.17	-1.15	5.30	0.805
Mx6-APerp	2.28	0.78	2.70	0.61	0.855
Mx6-PP	0.49	5.70	0.73	4.50	0.902
Mandibular dentoalveolar component					
IMPA	-7.53	2.41	-0.37	5.56	0.295
Md1-PgPerp	-0.13	2.89	-0.09	2.42	0.973
Md1-MP	-1.34	1.18	-1.09	1.16	0.944
Md6-PgPerp	-2.17	1.95	-2.21	1.26	0.992
Md6-MP	-0.64	1.84	-0.57	0.98	0.980
Dental relationships					
Overjet	0.09	0.90	0.11	1.25	0.947
Overbite	0.86	1.22	0.07	1.31	0.098
Molar relationship	0.09	0.43	0.78	0.46	<0.001*
OGS	-4.54	7.03	-3.67	8.85	0.778

*Statistically significant at $p < 0.05$.

2.2 ARTICLE 2

RELATIONSHIP BETWEEN MALOCCLUSION SEVERITY AND OCCLUSAL STABILITY IN CLASS II NONEXTRACTION TREATMENT

Introduction: The aim of this study was to evaluate the occlusal stability of Class II malocclusion nonextraction treatment, according to the initial anteroposterior discrepancy severity. **Methods:** Two groups of patients were selected and divided according to the initial Class II malocclusion severity. The Half-cusp Class II Group comprised 30 patients (16 boys, 14 girls) with an initial mean age of 13.15 years (S.D. 3.62) and the Complete Class II Group comprised 30 patients (15 boys, 15 girls) with an initial mean age of 11.99 years (S.D. 1.26). Dental casts and panoramic radiographs were obtained at pretreatment (T1), posttreatment (T2), and at a minimum period of 2 years posttreatment (T3). Intragroup comparisons of changes in variables during the posttreatment period (T3–T2) were made with paired t tests and between groups using the t test. A multiple linear regression analysis was used to evaluate the influence of pretreatment characteristics and amount of treatment changes in the amount of posttreatment relapse. **Results:** The intergroup comparison showed that during the posttreatment period there were no significant differences. The initial amount of canine and molar anteroposterior relationships and the amount of changes during treatment were significantly correlated to the amount of posttreatment molar relationship relapse. When subgroups of patients with matching treatment time were compared, there was significantly greater relapse in molar relationship in the Complete Class II Group. **Conclusions:** When treated without extractions, complete Class II malocclusion presented greater relapse than a less severe Class II molar relationship.

INTRODUCTION

Class II malocclusion treatment can be performed with many different appliances and protocols, which are selected according to the characteristics of the problem, such as the anteroposterior discrepancy, age, and patient compliance.¹ In

order to select the best approach, it is important to estimate which one will be the most efficient and stable.

It has been demonstrated that the initial severity of Class II malocclusion dental discrepancy is directly related to treatment efficiency.² On the other hand, it is still not clear if Class II severity may also influence long-term stability after successful treatment. Studies that assessed patients presenting Class II malocclusion have suggested that the greater the treatment changes are, the greater will be the relapse tendency of the dental relationships obtained.^{3,4} However, none of these studies have assessed groups of patients divided according to the initial Class II molar relationship severity.

Thus, it seems important to evaluate whether the nonextraction treatment approach in patients with more severe Class II dental discrepancies results not only in increased treatment time^{2,5} and need for patient compliance⁶ but also in greater relapse in the long-term. The consideration of these parameters prior to treatment would eliminate several retreatments and inconveniences in the relationship among doctor, patient, and parents⁷.

Stability of dental relationships is the most important aim to be achieved.⁸ Even though the posttreatment changes of the skeletal characteristics are useful for the researcher, it is also important to analyze the occlusal features, which are the major reasons for patients' complaints.⁹ Conversely, studies have mainly focused on cephalometric changes after treatment,^{4,10-12} when the occlusal analysis may enable a more precise evaluation of the dental relationship changes.¹³

Therefore, the aim of this study was to evaluate the occlusal stability of Class II malocclusion nonextraction treatment, according to the initial anteroposterior discrepancy severity.

MATERIAL AND METHODS

Ethical approval was obtained from the Ethics in Research Committee of Bauru Dental School, University of São Paulo, Brazil, before the study was conducted. The sample was retrospectively selected from the files of the orthodontic department at Bauru Dental School, University of São Paulo, Brazil, which include over 4000 documented treated patients.

The sample size was calculated based on an alpha significance level of 5% and beta of 20% to detect a mean difference of 0.34mm with a standard deviation of 0.46mm in molar relationship change between the posttreatment and follow-up stages.¹⁴ The sample size calculation showed that a sample size of 30 patients was needed.

Two groups of patients were selected and divided according to the initial Class II malocclusion severity. The Half-cusp Class II Group comprised 30 patients (16 boys, 14 girls) with bilateral half-cusp Class II malocclusion (molar relationship^{15,16}) at an initial mean age of 13.15 years (S.D. 3.62). The Complete Class II Group comprised 30 patients (15 boys, 15 girls) who initially had bilateral complete Class II malocclusion (molar relationship) at an initial mean age of 11.99 years (S.D. 1.26).

Molar relationships were assessed on the study casts, by using the location of the mesiobuccal cusp of the maxillary first molar and the mesial buccal groove of the mandibular first molar as reference points. Sample selection was based exclusively on the anteroposterior dental relationship at T1, regardless of any other dentoalveolar or skeletal characteristic.

The additional selection criteria were: (1) Presence of all permanent teeth up to the second molars at T2; (2) All patients should have been treated with a 1-phase treatment protocol without extractions; (3) Successful treatment to at least a Class I molar relationship.

Patients who were submitted to orthopedic treatment or who did not present any of the above mentioned criteria were automatically excluded from the study.

The mechanics in both groups consisted of standard fixed edgewise or Roth preadjusted appliances with 0.022 X 0.028-inch slots, associated with extraoral headgear to distalize the maxillary teeth or restrict their forward displacement. Class II elastics were also used when applicable, to aid in correcting the Class II anteroposterior relationship. The usual wire sequence was 0.015-in Twist-Flex or 0.016 Nitinol wire, followed by 0.016-, 0.018-, and 0.020-in, and finally a 0.021x0.025 or an 0.018 X 0.025-inch stainless steel archwires (all from 3M Unitek, Monrovia, Calif). Deep overbites were usually corrected by reversed and accentuated curves of Spee.

After the active treatment period, a Hawley plate was used for retention in the maxillary arch during a mean period of 1 year (6 months all day and 6 months

bedtime only), and a canine-to-canine fixed retainer was bonded in the mandibular arch and recommended to be maintained for at least three years.

Dental Cast Analyses

The records and the initial (T1), final (T2) and long-term posttreatment (T3 - at least 2 years) dental casts and panoramic radiographs of all patients were obtained.

All dental casts were digitized using the 3Shape R700 3D scanner (3Shape A/S, Copenhagen, Denmark). Dental casts were fixed to a plate and positioned on a three-axial drive system platform. To perform the digital measurements OrthoAnalyzerTM 3D software (3Shape A / S, Copenhagen, Denmark) was used.

The amount of Class II anteroposterior discrepancy of the posterior teeth in relation to a Class I relationship was measured as follows. Canine anteroposterior discrepancy was measured from the cusp tip of the maxillary canine to the interproximal region between the mandibular canine and first premolar (Fig 1A). Anteroposterior discrepancy of the first premolars was measured from the buccal cusp tip of the maxillary first premolar to the interproximal region between the mandibular first premolar and second premolar (Fig 1B). Anteroposterior discrepancy of the second premolars was measured from the buccal cusp tip of the maxillary second premolar to the interproximal region between the mandibular second premolar and first molar (Fig 1C). Molar anteroposterior discrepancy was measured from the mesiobuccal cusp tip of the maxillary first molar to the mesiobuccal groove of the mandibular first molar (Fig. 1D). The left and right measurements of each dental cast were averaged and used as a single variable. A positive reading indicated a Class II relationship.

To assess the occlusal and radiographic results and stability of orthodontic treatment the Objective Grading System (OGS), developed by The American Board of Orthodontics was used.¹³ This system for scoring dental casts and panoramic radiographs contains eight criteria: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulation.

Error study

A month after the first measurements, 30 radiographs and 30 dental study casts were randomly selected and remeasured by the same examiner (W.C.). The random errors were calculated according to Dahlberg's formula ($Se^2 = \sum d^2/2n$),¹⁷ and the systematic errors were evaluated with dependent t tests, at $P < 0.05$.¹⁸

Statistical analyses

Normal distribution was verified by Kolmogorov-Smirnov tests. The results were nonsignificant for all variables. Therefore, intergroup comparability regarding the ages at the different stages and observational periods were performed with t tests. Intergroup sex distribution was compared with chi-square tests.

Posttreatment changes intragroup comparisons (T3–T2) were performed with paired t tests. T tests were used to compare the intergroup posttreatment changes (T3–T2).

A multiple linear regression analysis was performed to determine the influence of the initial dental relationships severity (T1) and amount of correction obtained with treatment (T2–T1) on the amount of Canine and Molar Relationship relapse (T3–T2).

Results were regarded as significant at $P < 0.05$. These analyses were performed with Statistica for Windows 4.3B (Statsoft, Tulsa, Okla).

RESULTS

There were no systematic errors. The range of random errors were within acceptable levels and varied from 0.24 mm (Canine Relationship) to 1.03 (OGS).^{18,19}

During the posttreatment period (T2–T3) there were significant relapses of molar relationship for both groups (Table II).

The intergroup comparison showed that during the posttreatment period there were no significant differences between the posterior teeth anteroposterior changes (Tables III).

The multiple linear regression analysis showed that the initial amount of canine Class II relationship severity and the amount of canine, and first premolar relationship corrections with treatment were significantly correlated to the amount of canine Class II relationship increase posttreatment (Table IV). Similarly, the initial canine, first premolar and molar relationships severity and the amount of canine and molar relationship corrections with treatment were significantly correlated to the amount of molar Class II relationship increase posttreatment.

To evaluate whether treatment time (T2-T1) influenced the long-term posttreatment changes, subgroups with 15 patients of each group with the most comparable treatment times were compared (Table V). The results showed that first premolar, second premolar and molar relationships presented significantly greater relapse in the Complete Class II Group during the posttreatment period (T3-T2, Table VI).

DISCUSSION

It has been demonstrated previously that the amount of changes produced with treatment negatively influences posttreatment stability.^{3,4,20,21} Although it has been suggested that greater initial Class II molar relationships and consequently greater molar changes may result in less stability in the long-term,²⁰ to the best of our knowledge, this is the first study that compared Class II treatment stability between two groups of patients with actually distinct Class II molar relationship severities.

A similar study as this was conducted by De Lima et al.,²² to verify the influence of the initial Class II molar relationship severity on molar relationship stability after nonextraction treatment. However, the study sample was divided into two groups, one with patients presenting a 1/2-cusp or 3/4-cusp Class II molar relationships,¹⁵ and the other with patients presenting full-cusp Class II molar relationship. The problem in comparing these two groups lies in the fact that the initial severities of the Class II malocclusions may not be in fact much different, since the Half-cusp Class II Group also included patients with 3/4-cusp Class II severity, which is very close to the severity of a complete Class II. This fact, together with the small number of subjects in each sample (16 patients and 23 patients, respectively), probably explains why no difference in the relapses of molar, premolars and canine relationships could be found between groups.

In order to actually evaluate the influence of Class II initial discrepancy severity on treatment stability, only patients presenting bilateral half-cusp Class II or bilateral complete Class II malocclusions were included in the present study. Accordingly, it makes sense that if we aim to evaluate whether greater treatment changes result in greater relapse, only successfully treated patients with respect to the anteroposterior discrepancy should be assessed,⁶ otherwise the amount of changes obtained with treatment would not be significantly different between the

groups, after all. Thus, the present study only included patients successfully treated to at least a Class I molar relationship.

The Complete Class II Group presented a significantly longer treatment time (Table I). This result was expected since it has been demonstrated that the severity of the anteroposterior discrepancy of Class II malocclusion, when treated without extractions, can significantly increase treatment time.^{2,5,22} Moreover, when treating more severe malocclusions there may be greater concern with respect to the use of active retention after correction of the anteroposterior discrepancy, which may also increase treatment time, as will be discussed later.

During the posttreatment period both groups showed significant relapse of molar relationship correction (Table II). Although statistically significant, the small changes observed in molar relationship may not be considered clinically significant.

Similar results were observed in a previous study conducted by Fidler et al.,¹⁴ which examined the long-term stability of Class II division 1 malocclusions after a mean period of 14.0 years postretention in successfully treated cases. The study results found that during the posttreatment period, changes were small but statistically significant for molar relationship, premolar relationship, overjet, and overbite.

Uhde, Sadowsky and Begole,²³ who assessed the long-term stability of dental relationships after orthodontic treatment (12 to 35 years) in Class I and Class II patients treated with and without extractions, found that the mean posttreatment change was always toward Class II, however these changes were also small (smaller than 0.77mm). No statistically significant difference was detected between any of the sample groups.

Our results seem to support previous work finding only minor relapse in occlusal relationships after Class II correction when successfully treated patients are followed.¹⁴

Previous studies suggested that stability of the results is a function of posttreatment relationships and function.^{14,24,25} All patients included in the study were successfully corrected to a Class I molar relationship, and had good intercuspation at the end of treatment. However, it has been demonstrated that intercuspation might contribute to stability but cannot guarantee it, relapse may occur even with good intercuspation.^{26,27}

The intergroup comparison showed that during the posttreatment period there were no significant differences (Table III).

On the other hand, the multiple linear regression analysis showed that the initial canine relationship severity and the amount of canine and first premolar relationship corrections with treatment were the most important factors correlated to the amount of posttreatment canine relationship relapse (Table IV). Similarly, the amount of posttreatment molar relationship relapse was significantly correlated to the initial canine, first premolar and molar relationships severity and the amount of canine and molar relationship corrections with treatment (Table IV). These results are in agreement with previous studies that also found that the amount of changes in canine and molar relationships obtained with treatment were significantly correlated to greater posttreatment changes of dental relationships.^{4,21,22}

The fact that a positive correlation was found between several pretreatment characteristics and an inverse relationship was found between several treatment changes with the amount of posttreatment anteroposterior relapse even though no difference was found between the two Class II severity groups, suggests a tendency for relapse with increased amount of correction. Therefore, to evaluate whether treatment time (T2-T1) influenced the long-term posttreatment changes, subgroups with comparable treatment time were compared (Table V). The results showed that first premolar, second premolar and molar relationships presented significantly greater relapse in the Complete Class II Group during the posttreatment period (T3-T2, Table VI).

These results corroborate with previous studies that suggested that the greater the treatment changes are, the greater will be the relapse tendency of the dental relationships obtained.^{3,4,14,20,21}

Limitations of the present study include its retrospective nature and consequently the difficulty in obtaining precise data from patients' dental records regarding their compliance in the use of auxiliary devices and retentions. However, the absence of significant differences with respect to the long-term stability between the original groups may be explained by the fact that the increased treatment time in the original Complete Class II Group also involved an increased active retention time. Thus, the stability achieved was probably consequent to the amount of active retention used during the fixed appliance phase of treatment.^{11,28,29}

When 15 patients of each group with the most comparable treatment times were compared, there was significantly greater relapse in the Complete Class II Group. This result emphasizes the importance of not neglecting the necessary active retention time, especially in Class II malocclusion nonextraction treatment.^{5,11,30,31}

The comparison between subgroups with respect to canine relationship was probably not significant because these teeth already end treatment with a mesial angulation and less mesiodistal compensation than the posterior teeth³² and, therefore, tend to present less mesial movement during the posttreatment period.

Studies have shown that nonextraction treatment of half-cusp Class II malocclusion presents greater occlusal success rate, quality of dental relationships finishing and smaller treatment time than nonextraction treatment of complete Class II malocclusion, which means greater treatment efficiency.^{2,22} Complete Class II treatment, in turn, demonstrated greater efficiency with the 2 premolar extraction protocol than with the nonextraction protocol.³¹

Moreover, complete Class II nonextraction therapy, requires greater anchorage reinforcement, because the posterior segment must be distalized an average of 7 mm to achieve a Class I molar relationship at the end of treatment.³³ This is twice the amount required for a half-cusp Class II correction without extractions. Consequently, the need for anchorage reinforcement in those patients is twice as great, and treatment success depends even more on patient compliance.⁵

Based on the results obtained in the present study, clinical implications can be drawn with respect to the orthodontic treatment of complete Class II malocclusion. When treated without extractions, greater relapse in the long-term is expected than after nonextraction treatment of a less severe Class II molar relationship. However, long-term stability can be achieved if an adequate active retention period is respected after the anteroposterior correction.

Still, it is important to evaluate whether each complete Class II patient is likely to accept an expected longer treatment time than different protocols (i.e. two premolar extractions⁵) and to comply with treatment. A previous study found that 27.5% nonextraction treatment plans were reversed to 2 premolar extraction protocols because of poor patient compliance in using the headgear or removable functional appliance to correct complete Class II relationship.⁶

CONCLUSIONS

It was concluded that:

1. Molar relationship improvement obtained with treatment presented a mild but significant relapse during the posttreatment period in both groups.
2. The amount of posttreatment molar relationship relapse was significantly correlated to the initial canine, first premolar and molar relationship severities and to the amount of canine and molar relationship corrections with treatment.
3. When subgroups of patients with matching treatment time were compared, there was significantly greater relapse in molar relationship in the Complete Class II Group.
4. Therefore, when treated without extractions, complete Class II malocclusion presented greater relapse than a less severe Class II molar relationship.

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FIGURE CAPTIONS

Fig. 1. Dental relationships. **A**, Canine relationship measurement; **B**, First premolar relationship measurement; **C**, Second premolar relationship measurement; **D**, Molar relationship measurement.

Fig 1

Table I. Comparability of the experimental groups (t and chi-square tests)

Stage/Period	<u>Half-cusp Class II</u> n = 30		<u>Complete Class II</u> n = 30		p
	Mean	SD	Mean	SD	
Age T1	13.15y	3.62y	11.99y	1.26y	0.119 [†]
Age T2	15.71y	3.40y	15.50y	1.55y	0.765 [†]
Age T3	21.65y	4.97y	21.87y	3.54y	0.853 [†]
Treatment time	2.56y	1.22y	3.51y	1.65y	0.016 ^{†*}
Long-term follow-up time	6.04y	3.35y	6.47y	3.91y	0.670 [†]
Sex	Male 16 (53.3%)	Female 14 (46.7%)	Male 15 (50%)	Female 15 (50%)	0.796 [‡]

[†] t test; [‡] chi-square test.

*Statistically significant at $p < 0.05$.

Table II – Intragroup posttreatment changes – T3-T2 (Paired t tests)

	T2		T3		Difference		
Variable	Mean	SD	Mean	SD	Mean	SD	p
Half-cusp Class II (n=30)							
Canine Relationship	0.74	0.67	0.49	0.42	-0.24	0.89	0.143
1 st Premolar Relationship	1.04	0.76	0.95	0.83	-0.09	0.82	0.558
2 nd Premolar Relationship	1.20	0.78	1.21	0.93	0.01	0.75	0.965
Molar Relationship	0.03	0.58	0.35	0.68	0.32	0.65	0.011*
OGS	23.50	9.25	20.37	8.30	-3.13	8.50	0.053
Complete Class II (n=30)							
Canine Relationship	0.66	0.69	0.79	0.49	0.14	1.46	0.614
1 st Premolar Relationship	1.13	0.80	1.41	1.35	0.29	1.01	0.130
2 nd Premolar Relationship	1.54	0.71	1.94	1.53	0.40	1.28	0.100
Molar Relationship	0.38	0.42	0.84	1.13	0.46	1.07	0.026*
OGS	19.53	8.00	18.73	10.55	-0.80	10.91	0.691

*Statistically significant at $p < 0.05$.

Table III - Intergroup posttreatment changes comparison – T3-T2 (T tests)

Variable	<u>Half-cusp Class II</u> n=30		<u>Complete Class II</u> n=30		p
	Mean	SD	Mean	SD	
Canine Relationship	-0.24	0.89	0.14	1.46	0.228
1 st Premolar Relationship	-0.09	0.82	0.29	1.01	0.119
2 nd Premolar Relationship	0.01	0.75	0.40	1.28	0.154
Molar Relationship	0.32	0.65	0.46	1.07	0.540
OGS	-3.13	8.50	-0.80	10.91	0.359

Table IV – Results of multiple linear regression analysis with the amount of Canine Relationship and Molar Relationship relapse in the posttreatment period as the dependent variable (n=60)

Variables	Canine Relationship T3-T2		Molar Relationship T3-T2	
	r	p	r	p
Canine Relationship T1	0.76	0.002*	0.81	0.007*
1 st Premolar Relationship T1	0.80	0.108	0.93	0.011*
2 nd Premolar Relationship T1	0.24	0.616	0.15	0.670
Molar Relationship T1	0.19	0.648	0.65	0.033*
Canine Relationship T2-T1	-0.86	0.001*	-0.43	0.015*
1 st Premolar Relationship T2-T1	-0.62	0.049*	-0.39	0.083
2 nd Premolar Relationship T2-T1	-0.09	0.765	-0.22	0.313
Molar Relationship T2-T1	-0.22	0.488	-0.60	0.009*

*Statistically significant at $p < 0.05$.

Table V. Comparability of the experimental subgroups with comparable treatment time (T and chi-square tests)

Stage/Period	<u>Half-cusp Class II</u> n = 15		<u>Complete Class II</u> n = 15		p
	Mean	SD	Mean	SD	
Age T1	12.47y	2.03y	12.45y	1.26y	0.975 [†]
Age T2	15.33y	2.14y	15.41y	1.36y	0.898 [†]
Age T3	20.21y	3.69y	22.31y	3.88y	0.141 [†]
Treatment time	2.85y	0.94y	2.96y	1.37y	0.811 [†]
Long-term follow-up time	4.89y	2.56y	6.90y	3.81y	0.101 [†]
Sex	Male 3 (20%)	Female 12 (80%)	Male 5 (33.3%)	Female 10 (66.7%)	0.409 [‡]

[†] t test; [‡] chi-square test.

Table VI - Intergroup comparison of posttreatment changes – T3-T2 in subgroups with comparable treatment time (t test)

Variable	<u>Half-cusp Class II</u> n = 15		<u>Complete Class II</u> n = 15		p
	Mean	SD	Mean	SD	
Canine Relationship	-0.59	0.47	-0.08	1.90	0.376
1 st Premolar Relationship	-0.54	0.60	0.61	1.41	0.018*
2 nd Premolar Relationship	-0.28	0.74	0.94	1.28	0.010*
Molar Relationship	0.26	0.48	0.63	0.96	0.040*
OGS	-3.67	8.85	-4.54	7.03	0.778

*Statistically significant at $p < 0.05$.

3 DISCUSSION

3 DISCUSSION

Although it has been demonstrated that the initial severity of Class II malocclusion dental discrepancy is directly related to treatment efficiency (JANSON et al., 2009a), it was still not clear whether the initial Class II severity presents an important influence on the long-term posttreatment stability. Therefore, the aim of the studies here presented was to evaluate the cephalometric and occlusal Class II malocclusion nonextraction treatment stability, according to the initial anteroposterior discrepancy severity.

To be able to evaluate whether greater treatment changes results in greater relapse, only patients presenting a bilateral half-cusp Class II malocclusion or a bilateral complete Class II malocclusion were included in the present study. Accordingly, only successfully treated patients with respect to the anteroposterior discrepancy were assessed (JANSON et al., 2006), otherwise the amount of changes obtained with treatment would not be significantly different between groups after all.

A similar study as this was conducted by De Lima et al. (DE LIMA et al., 2013), which also verified the influence of the initial Class II molar relationship severity on molar relationship stability after nonextraction treatment. However, the study sample was divided into two groups that did not present actually distinct Class II severities, since the half-cusp Class II Group also included patients with $\frac{3}{4}$ -cusp Class II severity. This fact, probably explains why no difference in the relapses of molar, premolars and canine relationships could be found between groups.

It seems logical that greater Class II anteroposterior corrections take more time, when treated nonextraction (JANSON et al., 2007; JANSON et al., 2009b; DE LIMA et al., 2013). Accordingly, in the present study, the Complete Class II Group presented a significantly longer treatment time. Moreover, when treating more severe malocclusions there may be greater concern with respect to the use of active retention after the correction of the anteroposterior discrepancy, which may also increase treatment time, as will be discussed later.

During the posttreatment period both groups showed a slight but significant relapse of the molar relationship (0.32 mm for the Half-cusp Class II Group and 0.46mm for the Complete Class II Group; Table II). Although statistically significant,

the small changes observed in molar relationship may not be considered clinically significant.

Similar results were observed in previous studies (UHDE; SADOWSKY; BEGOLE, 1983; FIDLER et al., 1995). Uhde, Sadowsky and Begole (UHDE; SADOWSKY; BEGOLE, 1983), found that the mean posttreatment change was always toward Class II, however these changes were also small (fewer than 0.77mm) and no statistically significant difference was detected between Class I and Class II treated patients or between extraction and nonextraction protocols.

Our results seem to support previous work finding only minor relapse in occlusal relationships after Class II correction when successfully treated patients are followed (FIDLER et al., 1995). Previous studies suggested that the stability of the results is a function of posttreatment relationships and function (MCNAMARA, 1975; PANCHERZ, 1985; FIDLER et al., 1995). However, it has been demonstrated that intercuspation might contribute to stability but cannot guarantee it, relapse may occur even with good intercuspation (EL-MANGOURY, 1979; FERRO et al., 2003).

The intergroup comparison showed that during the posttreatment period there were no significant differences between groups with respect to cephalometric or occlusal changes.

On the other hand, the multiple regression analysis demonstrated that several initial characteristics and treatment changes presented an influence on the amount of posttreatment relapse. The initial amount of overjet, initial canine, first premolar and molar relationships severities were correlated to the molar relationship relapse towards Class II during the posttreatment period (Molar Relationship T3-T2). With respect to treatment changes, the amount of canine and molar relationship corrections were significantly correlated.

These results are in agreement with previous studies that also found that the amount of changes in in overjet, overbite, and in canine and molar relationships obtained with treatment were significantly correlated to greater posttreatment changes of dental relationships (JANSON et al., 2009a; JANSON; ARAKI; CAMARDELLA, 2012; DE LIMA et al., 2013). It seems that studies that have not assessed only successfully treated patients fail to find this correlation, since the absence of this selection parameter may result in smaller treatment changes and consequently in smaller posttreatment relapse (FIDLER et al., 1995; JANSON et al., 2010; JANSON; ARAKI; CAMARDELLA, 2012).

The fact that a positive correlation was found between several pretreatment characteristics and an inverse relationship was found between several treatment changes with the amount of posttreatment anteroposterior relapse (overjet and molar relationship), even though no difference was found between the two Class II severity groups, suggests a tendency for relapse with increased amount of correction, as observed previously (NASHED; REYNOLDS, 1989; YAVARI et al., 2000; JANSON et al., 2004; JANSON et al., 2009a; JANSON; ARAKI; CAMARDELLA, 2012).

Additionally, it seems that the quality of the occlusal results obtained also play a role in posttreatment relapse (EL-MANGOURY, 1979), since a positive correlation was observed between the quality of the occlusal results at the end of treatment and the amount of occlusal status relapse after treatment.

To evaluate whether treatment time influenced the long-term posttreatment changes, subgroups with comparable treatment time were compared. The results showed that first premolar relationship (occlusal analysis) and molar relationship (cephalometric and occlusal analyses presented significantly greater relapse in the Complete Class II Group during the posttreatment period.

These results corroborate with previous studies that suggested that the greater the treatment changes are, the greater will be the relapse tendency of the dental relationships obtained (NASHED; REYNOLDS, 1989; FIDLER et al., 1995; YAVARI et al., 2000; JANSON et al., 2009a; JANSON; ARAKI; CAMARDELLA, 2012).

The findings of the present study must be interpreted in the light of the limitations of its retrospective nature, such as the difficulty in estimating the accuracy of data obtained from the dental records with respect to patient compliance in the use of auxiliary devices and retentions. However, the absence of significant differences with respect to the long-term stability between the original groups may be explained by the fact that the increased treatment time in the original Complete Class II Group also involved an increased active retention time. Thus, the stability achieved was probably consequent to the amount of active retention used during the fixed appliance phase of treatment (JANSON et al., 2004).

When 15 patients of each group with the most comparable treatment times were compared, there was significantly greater relapse in molar relationship in the Complete Class II Group. This result emphasizes the importance of not neglecting

the necessary active retention time, especially in Class II malocclusion nonextraction treatment (JANSON et al., 2007; JANSON et al., 2010).

The complete Class II nonextraction therapy, requires greater anchorage reinforcement, because the posterior segment must be distalized twice the amount required for a one half-cusp Class II correction to achieve a Class I molar relationship at the end of treatment (NANGIA; DARENDELILER, 2001). Consequently, the need for anchorage reinforcement in those patients relies substantially on patient compliance (JANSON et al., 2007). Moreover, lower treatment efficiency (lower occlusal success rate, quality of dental relationships finishing and greater treatment time) is expected when treating these patients without extractions (JANSON et al., 2009b; DE LIMA et al., 2013).

The results obtained in the present study provide important clinical implications for the orthodontic treatment of dental Class II malocclusion. When treated without extractions, complete Class II malocclusion may present greater relapse than a less severe Class II molar relationship. However, a severe Class II malocclusion should not discourage nonextraction treatment, with respect to the long-term success of treatment results, if an adequate active retention period is respected after anteroposterior correction.

Still, it is important to evaluate whether each complete Class II patient is likely to accept an expected longer treatment time than different protocols (i.e. two premolar extractions (JANSON et al., 2007)) and to comply with treatment.

4 FINAL CONSIDERATIONS

4 FINAL CONSIDERATIONS

The following conclusions were drawn on the basis of the two studies:

1. Molar relationship improvement obtained with treatment presented a mild but significant relapse during the posttreatment period in both groups.
 2. The initial amount of overjet and the amount of treatment changes in molar relationship were significantly correlated to the long-term posttreatment overjet and molar relationship relapse.
 3. Additionally, the multiple linear regressions analysis of the occlusal features demonstrated that the amount of posttreatment molar relationship relapse was significantly correlated to the initial canine, first premolar and molar relationships severity and the amount of canine and molar relationships correction with treatment.
 4. When subgroups of patients with matching treatment time were compared, there was significantly greater relapse in molar relationship in the Complete Class II Group.
 5. Therefore, the initial Class II malocclusion anteroposterior discrepancy severity demonstrated a significant influence on the amount of posttreatment relapse. When treated without extractions, complete Class II malocclusion presented greater relapse than a less severe Class II molar relationship.
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APPENDIXES

APPENDIXES

APPENDIX A – Declaration of exclusive use of the article 1 in thesis.

DECLARATION OF THE USE OF THE ARTICLE IN THESIS

We hereby declare that we are aware that the article "Relationship between malocclusion severity and treatment stability in Class II nonextraction treatment" will be included in the thesis of the student Waleska Trovisco Caldas and may not be used in other works of Graduate Programs at the Bauru Dental School, University of São Paulo.

Bauru, January 15th of 2018.

Waleska Trovisco Caldas

Signature

Guilherme Janson

Signature

APPENDIX B - Declaration of exclusive use of the article 2 in thesis.

DECLARATION OF THE USE OF THE ARTICLE IN THESIS

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ANNEXES

ANNEXES

ANNEX A – Research Institutional Board approval, protocol number 59804416.5.0000.5417

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Pesquisador: WALESKA TROVISCO CALDAS

Área Temática:

Versão: 3

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Idem ao parecer 1.745.643 de 26 de setembro de 2016.

Objetivo da Pesquisa:

Idem ao parecer 1.745.643 de 26 de setembro de 2016.

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Comentários e Considerações sobre a Pesquisa:

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ANNEX B - Guidelines for AJO-DO submissions: Original Article

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AUTHOR INFORMATION PACK

TABLE OF CONTENTS

• Description	p.1
• Impact Factor	p.1
• Abstracting and Indexing	p.1
• Editorial Board	p.2
• Guide for Authors	p.3

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